FAST Industry Day
2 October 2007
Questions and Answers

To submit additional questions to the FAST Program Office, please send it by email to the BAA Mailbox BAA07-65@darpa.mil

Q: Is power storage included in the 130 W/kg metric?
A: No, but proposed approaches that include batteries or other energy storage mechanisms in the HPGS mass will be considered favorably.

Q: What is the nominal collector dimension?
A: We are interested in a 20 kWe ground demonstration capability, and 50-80 kWe or more for a notional operational system. Assume an incident solar flux in earth orbit of 1352 W/m^2. Calculations of collector dimensions should be based on this assumption.

Q: Why specify 40:1 to 100:1 concentration ratios, if a lower concentration ratio such as Entech's stretched lens array at 8:1 will satisfy requirements?
A: If your conceptual approach can incorporate lower levels of concentration and still achieve the 130 W/kg HPGS goal, that is acceptable. The values of 40:1 to 100:1 were based on the results of a 2005 seedling study. You are not limited to this range.

Q: How important is radiation hardening? Hardening against laser threats? ESD (electrostatic discharge)?
A: Individual performers should evaluate each of these concerns and describe mitigation strategies in their proposals, if they deem them to be significant. No radiation hardened parts are required in the ground testing of the HPGS, envisioned to occur in Phases 1/2. Performers will need to indicate how their conceptual approach will survive in the space environment. There is no laser threat requirement in the BAA.

Q: Would simulation of the HPGS in Phase 1 be stronger if it was configured for a specific electric propulsion and PMAD system that would meet the spaceflight requirements in GEO?
A: No. We are interested in a flexible power system, one which is capable of pairing with different types of electric propulsion systems, as well as high power payloads.

Q: How low of an initial altitude should the FAST technology be able to accommodate?
A: Not so low that your conceptual FAST demonstrator will be unable to overcome its own drag at LEO altitudes.

Q: Must the demonstration actually fly to GEO or can it demonstrate the HPGS in LEO?
A: Phases 1 and 2 of FAST focus on a ground-based demonstration of the HPGS. You are free to propose follow-on space demonstrations in any flight regime; they need not necessarily even include propulsion (i.e., we are obviously very interested in promoting agile, maneuverable systems, but we recognize the value that high specific power has across-the-board, for communications and active sensing).

Q: What sponsors have you contacted for an on-orbit demonstration, and what was their initial response?
A: We have discussed the FAST concept with various sponsors, and feedback was favorable; however, most will want to wait on initial results before committing to anything. We will continue to pursue sponsor support throughout the effort.

Q: Is the demonstration sub-scale fixed at 570 kg/1000 kg or could it be smaller?
A: No, it is not fixed at 570 kg; this figure was derived from our 2005 seedling study, which examined the use of a small booster—specifically, SpaceX's Falcon 1—for a notional space demonstration to follow Phases 1/2. If you feel that you can meet the intent of the HPGS demonstration with a smaller system, please do so.

Q: For designing the radiation protection elements, we'll need to know the mission duration at GEO. What is your vision for time to end-of-life?
A: Nominal mission lifetime will be dependent on the operational system's mission, which has been left unspecified. We would expect potential performers to address this issue as a risk item, and discuss possible mitigation strategies, given a range of mission lifetimes.

Q: What is total delta V for the demonstration and total delta V for the operational system?
A: A spiral transfer from circular, low-inclination LEO to an equatorial GEO requires approximately 6 km/s of velocity change. Repositioning maneuvers at GEO may require up to several hundreds of m/s per move. We estimate a total of 8 km/s of velocity change would be required for a demonstration comprising a LEO-GEO transfer followed by multiple GEO

maneuvers. Your analysis may be different, depending on what you propose.

Q: Solar "rockets" have been looked at for at least 3 decades. There was also a serious effort with respect to concentrators a few years ago that almost made it into a space demo. Why were earlier efforts terminated?
A: We suggest you query individuals who were directly responsible for these efforts, as part of your initial literature survey.

Q: Who performed the FAST seedling study, including designing and sizing?
A: The 2005 study was performed by a team including StarVision, Pratt & Whitney Rocketdyne, and Millenium, along with some support from JHU's Applied Physics Lab. This effort was completed a little over one year ago.

Q: Define all components of the HPGS.
A: Broadly, the HPGS includes all elements of the power collection, conversion, and distribution system, from the point at which solar photons initially strike the system, until electrical current (at an appropriate voltage) is supplied across an interface to a high-power payload or electric propulsion device. This includes waste heat rejection. We do not require potential performers to include energy storage in the HPGS, although we are very interested in approaches which do include batteries or alternatives to batteries.

Q: The FAST video illustrated numerous potential applications. Is DARPA seeking a single technology solution? Or does DARPA want multiple solutions that may scale differently for various orbital applications?
A: We expect that there are many ways to meet our stated goals of developing a 20 kWe, 130 W/kg HPGS. For DARPA, it is sufficient to get to the end of Phases 1/2 with a single solution, taking the "technical excuse off the table" for high specific power systems.

Q: For the 40 W/kg spacecraft metric, what is included in the mass?
A: This figure is based on the results of our 2005 seedling study. It includes the entire spacecraft mass as delivered to orbit, including spacecraft propellant. High spacecraft specific power—in this case, 40 W/kg—enables rapid orbit transfers between LEO and GEO, and rapid repositioning in GEO.

For Phases 1/2, the emphasis is on building the HPGS at a subsystem specific power level of 130 W/kg or better. The first application of FAST HPGS technology may be to prime payloads, rather than for propulsive use.

Q: What is the thruster load voltage level?

A: Thruster (or payload) voltage level is dependent on the actual electric thruster or payload suite(s) proposed. No specific electric propulsion approach has been specified.

Q: Is there information available regarding previous related studies?
A: We will make related study information available on our FAST website.

Q: [DARPA states that] the electric propulsion thruster is not part of the HPGS, but there seems to be a lack of clarity regarding whether the EP power conversion and control is considered part of the HPGS or propulsion. For a non-direct drive scenario, a typical power conversion unit might require ~2 kg/kW (a substantial mass impact). While this mass is greatly reduced for a direct drive, there is still some content required in [EP power conversion and control].
A: One approach we could take is to publish an interface control document, demand that only basic power management and distribution stay inside the HPGS, but must output 28V at up to (say) 750A. Then you could hook up whatever step-up or step-down transformers you like outside the HPGS, and they wouldn't count against the 20 kWe @ 130 W/kg requirement.

This creates a massive loophole that perpetuates the existing paradigm.

You should consider how you would power both electric propulsion systems and very high power payloads (e.g., lidar or radar), assuming they all "plug in" to a common PMAD, at the stated specific power and absolute power figures. If all you can do is direct-drive the EP, you've got a great tug but a terrible back end for a comsat or GEO-based "first responder". The DARPA goal is to produce something a bit more flexible.

Q: Will the BAA ask proposers to include both Phases 1 and 2?
A: Yes (with Phase 2 as an executable option).

Q: Will the performer briefings [presented at FAST Industry Day] be made available online?
A: No.